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A best-practice approach for extreme sea level analysis along complex topographic coastlines

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Million of European coastal properties are currently at risk from coastal flooding. Any increase in flood frequency or severity, due to sea level rise or changes in storminess, would impact on economic and social systems, as well as fragile ecosystems. Extreme sea levels result from a number of components including global mean sea level, regional trends, land movements, plus any alteration to the tidal regime or storm surge characteristics due to these changes. It is essential that statistical information on coastal extremes is both up to date and accessible by decision makers and coastal engineers. Previous work in the UK has shown that a Revised Joint Probability Method (RJPM), that exploits knowledge of the interaction between tide and storm surge, offers considerable improvements over annual maximum methods that then fit a generalised extreme value distribution (GEV) to observed sea level maxima. Here we update and extend the RJPM techniques to account for improved statistical tools for making choices of thresholds and key parameters. We adopt three different approaches to estimating the return levels of extreme sea level from quality-controlled tide gauge data. Firstly, we employ functions of the tide to perform a location-scale normalisation of non-tidal residuals and then obtain the distribution parameters using a point-process method; secondly, we construct the joint probability functions of tide and surge directly within a number of discrete tidal bands; finally, we calculate joint probability of the skew surge (the time-independent difference between peak prediction and observations) with the tide. We use an ensemble of these three sets of local estimates to calibrate the corresponding return levels provided by a suite of hydrodynamic models, all forced by the ERA40 1º dataset. The estimates at the sites themselves are more reliable than any previous calculations because of improved methodology and the increased length of tide gauge data. The high-resolution models create a means of dynamical interpolation and thus deliver a consistent spatial method for estimating extreme sea levels around the entire UK coastline, including complex topographic regions. This work provides the most reliable scientific basis for estimating extreme water levels around the UK coast, and the method can be extended elsewhere with ease. The results are directly applicable to flood and coastal defence policy.